

CHAPTER 1

FY 2007 BENEFITS ESTIMATES

The Office of Energy Efficiency and Renewable Energy (EERE) estimates expected benefits for its overall portfolio and for each of its nine programs. Benefits for the FY 2007 budget request¹ are estimated for the midterm (2010-2025) and long term (2030-2050). Two separate models suited to these periods are employed—NEMS-GPRA07 for the midterm and MARKAL-GPRA07 for the long term.

Benefits estimates are intended to reflect the value of program activities from 2007 forward. They do not include the impacts of past program success, nor technology development or deployment efforts outside EERE's programs. This distinction is difficult to implement in practice, because many research and deployment activities provide continuous improvements that build on past success; and because EERE programs are leveraged with private-sector and other government efforts (e.g., in addition to the Baseline Case, private-sector improvements).

Outcomes and Benefits Metrics

The energy efficiency improvements and additional renewable energy production facilitated by EERE's programs reduce the consumption of traditional energy resources. Reducing energy consumption affords the Nation a number of economic, environmental, and energy security benefits.² The extent of these benefits depends on numerous factors including which energy sources are reduced, the costs of the new technologies, and the emissions performance of the energy technologies used. Different EERE portfolios would produce a different mix of benefits, even if the overall level of primary energy savings were the same.

The public benefits resulting from these reductions in the use of traditional energy resources take many forms. Environmental improvements, for instance, can include reductions in local, regional, or global air emissions; reduced water pollution; noise abatement, etc. These public benefits are typically difficult to measure directly, and some aspects are not quantifiable. EERE has developed a set of *indicators* intended to provide a sense of the magnitude and range of the benefits its programs provide to the Nation. EERE estimates benefits for the following defined metrics:

Energy Displaced - the difference in nonrenewable energy consumption with and without the technologies and market improvements developed by EERE programs.

Analysts measure energy savings on a primary basis, accounting for the energy consumed in

¹EERE budget-request materials may be accessed at http://www1.eere.energy.gov/ba/pba/budget_formulation.html

² This is a categorization of EERE's benefits estimates, based on the framework developed by a National Research Council (NRC) committee. The framework is described in more detail in the Preface.

producing, transforming, and transporting energy to the final consumer. Energy savings from underlying private-sector improvements in technologies are not counted. Energy displaced is reported in quadrillion Btus per year (quads/yr).

Economic Benefits: Economic benefits are the potential for EERE technologies to make energy more affordable by reducing expenditures on energy and energy services, increase economic productivity and GDP through more efficient production processes, reduce the impact of energy price volatility on the U.S. economy by providing more efficient technologies and providing alternative energy sources, and improve the balance of trade by exporting energy technologies. Of these, EERE currently estimates two aspects of affordability—energy-expenditure savings and total system net cost savings:³

Energy-expenditure savings – The difference in total consumer energy bills with and without the availability of technologies and market improvements developed by EERE technologies. This is an estimate of energy bill savings⁴ and does not include all incremental costs to end users of acquiring the new technology. The NEMS model does not currently have the capability to directly calculate net cost savings.⁵ Energy-expenditure savings are reported in billions of 2003 dollars per year.

Total system net cost savings – The difference in total system costs with and without the availability of technologies and market improvements developed by EERE technologies. Total system cost represents the economic cost to society to produce, import, convert, and consume energy. It is calculated as the sum of domestic resource-extraction costs, imported fuel costs, and the annualized capital and operating and maintenance costs of energy technologies (including end-use demand devices). Total system net cost savings is a net estimate of system costs generated by MARKAL-GPRA07; which, unlike the energy expenditure savings estimates generated by NEMS-GPRA07, includes the incremental costs of end-use technologies. Total system net cost savings are reported in billions of 2003 dollars per year.

Environmental Benefits: Environmental benefits that can result from use of EERE technologies include, among many others, lower carbon, SO_x, NO_x, and other air emissions.⁶ Of these, EERE currently estimates only the impacts of its programs on carbon emissions:

Carbon savings (i.e. emission reductions) – The difference in the level of U.S. energy-related carbon emissions with and without the availability of EERE technologies and associated market improvements. Carbon emission reductions result from the reductions in fossil fuel consumption when these new supply (renewables) and

³ Energy-expenditure savings are calculated through 2025 using the NEMS-GPRA07. Total system net cost savings are calculated through 2050 using MARKAL-GPRA07.

⁴ Energy efficiency improvements and increased use of nonfuel renewable energy (e.g., renewable-generated electricity) reduce energy bills in two ways. Consumers who make energy efficiency or renewable energy investments benefit directly through reduced purchases of energy (quantity component). In addition, the lower demand for energy reduces the price of energy for all consumers (price component).

⁵ In future GPRA benefits reports, we expect the NEMS-GPRA model to show a net economic metric, in addition to the consumer expenditures it currently reports.

⁶ Because the level of emissions of many air pollutants is “capped” by the U.S. Environmental Protection Agency, in some cases EERE technologies may make compliance with the caps more cost-effective or less costly, but may not actually lower emissions.

demand (energy-efficient) technologies are used in the market. As with the energy-savings metric, emission reductions count the effect of upstream energy savings in producing, transforming, and transporting energy to the end user. Carbon savings are reported in million metric tons of carbon equivalent (mmtce) per year.

Security Benefits: Security benefits include improvements in the reliability of fuel and electricity deliveries, reduced likelihood of supply disruptions, and reduced impacts from potential energy disruptions. EERE contributes to these security gains by reducing U.S. reliance on imported fuels, increasing the diversity of domestic energy supplies, increasing the flexibility and diversity of the Nation's energy infrastructure, and reducing peak demand pressure on that infrastructure. Of these aspects of energy security, EERE has developed indicators related to concerns about fuel supplies and the reliability and diversity of electricity supplies.⁷

Oil savings – The difference in total U.S. oil consumption with and without EERE technologies and market improvements. Oil savings are reported in million barrels per day (mbpd).

Natural gas savings – The difference in total U.S. natural gas consumption with and without EERE technologies and market improvements. Natural gas savings are reported in quadrillion Btu per year (quads/yr).

Avoided additions to central conventional power – The difference in central conventional power additions with and without EERE technologies and market improvements. Avoided central conventional power additions result from electricity capacity displaced by efficiency improvements, and central renewable power-generating capacity.⁸ Avoided capacity additions are reported in cumulative gigawatts (GW).

In interpreting these metrics, it is important to remember that while the benefits of efficiency and renewable technologies are multifaceted, they are not always distinct or additive. Improvements in balance-of-trade or economic productivity, for instance, are contributory to improved GDP and not additional to improved GDP. Nonetheless, identifying the various types of economic or other contributions can help relate EERE's portfolio to various economic or other policy concerns.

Portfolio Benefits

Table 1.1 shows the estimated economic, environmental, and security benefits of EERE's overall portfolio of investments in improved energy-efficient technologies, renewable energy technologies, and assistance to consumers in adopting these technologies. Data by five-year

⁷ The inclusion of reliability improvements within the security category was part of the NRC suggestions on how to structure the types of EERE benefits.

⁸ These measures are not additive and are not the same as a measure of peak-load reduction for conventional electricity or of improved reliability. Renewable capacity additions are not equivalent to capacity additions avoided because of differences in capacity factors and coincidence of renewable generation at system peak (i.e. peak electricity-generation output of wind, for example, may not coincide with the peak demand of the utility system to which it supplies power).

increments (2010 to 2025) are shown for NEMS-GPRA07 and by 10-year intervals (2030 to 2050) for MARKAL-GPRA07.⁹

Table 1.1. Annual EERE Portfolio Benefits for FY 2007 Budget Request for Selected Years^{10,11}

EERE Midterm Benefits (NEMS-GPRA07)	2010	2015	2020	2025
Energy Displaced				
• Primary nonrenewable energy savings (quadrillion Btu/yr)	0.35	1.4	4.4	7.8
Economic				
• Energy-expenditure savings (billion 2003 dollars/yr)*	2.1	18	70	107
Environment				
• Carbon dioxide emission reductions (mmtce/yr)	8	26	86	166
Security				
• Oil savings (mbpd)	0.03	0.43	1.07	1.69
• Natural gas savings (quadrillion Btu/yr)	0.07	0.35	1.04	0.82
• Avoided additions to central conventional power (cumulative gigawatts)	0.53	11	54	118

EERE Long-Term Benefits (MARKAL-GPRA07)	2030	2040	2050
Energy Displaced			
• Primary nonrenewable energy savings (quadrillion Btu/yr)	14	25	32
Economic			
• Energy-system net cost savings (billion 2003 dollars/yr)*	63	138	207
Environment			
• Carbon dioxide emission reductions (mmtce/yr)	279	527	648
Security			
• Oil savings (mbpd)	3.9	8.0	11
• Natural gas savings (quadrillion Btu/yr)	2.0	2.0	2.8

* Midterm energy-expenditure savings only include reductions in consumer energy bills, while long-term energy-system net cost savings also include the incremental cost of the advanced energy technology purchased by the consumer.

Energy Displaced: In 2005, Americans consumed 95 quadrillion Btus of nonrenewable energy. Absent the results of EERE's programs,¹² annual consumption of nonrenewable energy could grow by 28 quads from 2005 to 2025, to about 123 quadrillion Btus of energy per year; and by 41 quads from 2005 to 2050, to about 136 quadrillion Btus of energy per year. If the goals of EERE's investment portfolio are achieved and the corresponding market outcomes realized, it will reduce nonrenewable energy consumption by 8 quadrillion Btus by 2025, or about 28% of the expected incremental growth in energy demand over this time period; and by 32 quadrillion Btus by 2050, or about 78% of the expected incremental

⁹ NEMS-GPRA07 runs using one-year intervals, while Markal-GPRA07 runs using five-year intervals.

¹⁰ Estimates reflect the annual benefits in each year associated with program activities from FY 2007 to the benefit year, or to program completion (whichever is nearer), and are based on program goals developed in alignment with assumptions in the President's Budget. Midterm program benefits were estimated using the GPRA07-NEMS model, based on the Energy Information Administration's (EIA) National Energy Modeling System (NEMS) and using the EIA's *Annual Energy Outlook 2005* (AEO2005) reference case. Long-term benefits were estimated using the GPRA07-MARKAL model developed by Brookhaven National Laboratory. Results can differ among models, due to structural differences. The models used in this analysis estimate economic benefits in different ways, with MARKAL reflecting the cost of additional investments required to achieve reductions in energy bills.

¹¹ For some metrics, the benefits estimated by MARKAL-GPRA07 do not align well with those reported by NEMS-GPRA07. Every attempt is made in the integrated modeling to use consistent baselines, input data, and assumptions in both models to produce consistent results. However, NEMS and MARKAL are, in some respects, fundamentally different models (see Boxes 2.1 and 3.1). Discrepancies in the estimated benefits often occur simply because of these model differences.

¹² See the Preface, and Appendix A for information on how EERE's "no-program" Baseline Case is developed.

growth in annual energy demand over this time period (see **Figure 1.1**). This results in a declining demand for nonrenewable energy consumption starting in 2030, despite a growing economy.

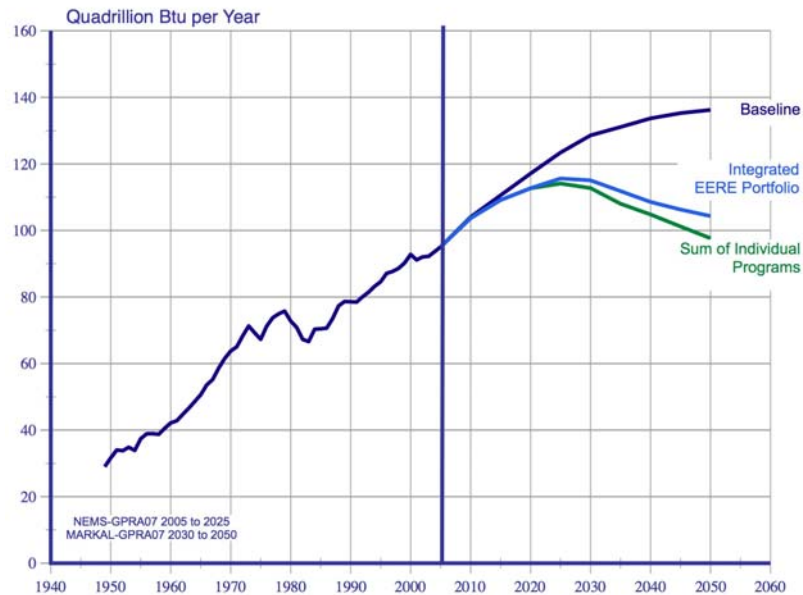


Figure 1.1. U.S. Nonrenewable Energy Consumption, 1949-2005, and Projections to 2050: Baseline, Individual Program Goal Cases and EERE Portfolio Case

Data Source: 1949-2005, Energy Information Administration, *Annual Energy Review 2004*, DOE/EIA-0384 (2004) (Washington, D.C., August 2005), Table 1.1 Web site <http://www.eia.doe.gov/emeu/aer/contents.html>.

Individual Program versus Portfolio Benefits

As discussed in the **Preface**, two sets of benefits are determined: a set of individual program goal cases and a portfolio case. The individual program goal cases are based on modeling the impact of each EERE program on its own, without the potential overlap or synergies that occur in the portfolio case. While some program activities reinforce each other to produce larger benefits than would be evident from each program's individual efforts, programs compete for the same markets in other cases. For example, the various renewable technology programs compete in the electricity-generation market. In addition, activities being funded by some programs reduce the potential market for technologies being developed in other programs. As an example, reductions in electricity demand due to efficiency improvements reduce the size of the generation market and, therefore, the market opportunity for renewable-generation technologies. A comparison of the "Sum of Program" and "Portfolio" curves shown in **Figure 1.1** illustrates the overall effect of these interactions among the programs. Estimated energy savings of the portfolio case are almost 2 quads less in 2025, compared to the sum of the individual program benefits; and almost 7 quads less in 2050, compared to the sum of the individual program benefits.

Supply Side and Demand Side Effects of EERE's Portfolio

To understand the relative contributions of EERE's portfolio on supply and demand, one needs to consider the total primary energy consumption changes associated with EERE's

portfolio, and not just the nonrenewable energy savings (see [Figure 1.2](#)). Total annual U.S. primary energy consumption—without the benefits of EERE’s portfolio—increases by 32 quads over the period of 2005 to 2025 to almost 134 quads per year, eventually increasing by 48 quads to a level of 150 billion quads per year in 2050. Accomplishment of the goals and associated market outcomes of EERE’s technology portfolio reduces total primary energy consumption in 2025 by 5 quads per year, or about 15% of the incremental growth over that period; and by 24 quads per year in 2050, or 50% of the incremental growth over that period. By 2025, total primary energy consumption actually begins to decline slightly. As [Figure 1.2](#) shows, the rate of decline in nonrenewable energy consumption is greater than the rate of decline in total energy demand. The difference reflects the supply-side impacts of replacing nonrenewable energy resources with renewable energy resources.

In 2025, increased use of renewable energy accounts for 37% (or 3 out of 8 quads) of the annual nonrenewable energy savings generated by the EERE portfolio. About 25% of the annual nonrenewable energy savings (or 8 out of 32 quads) in 2050 is accounted for by increased use of renewable energy resources (see [Figure 1.3a](#)). Over the period of 2008 to 2025, EERE’s portfolio adds a cumulative total of 25 quads of renewable energy over the amount that would have been used in the United States without these programs (see [Figure 1.3b](#)). Cumulative additions to use of renewable energy amount to just more than 170 quads by 2050. Cumulative savings in nonrenewable energy are 147 quads over the period of 2008 to 2025 and almost 600 quads by 2050. The differences between nonrenewable energy savings and use of renewable energy represent improvements in energy efficiency (that is, reductions in total primary energy demand).

While some of the technologies in EERE’s portfolio focus strictly on energy efficiency or renewable energy production and use, many address both. Vehicle technologies, for example, reduce nonrenewable energy consumption through improvements in vehicle efficiency and through the introduction of vehicles capable of utilizing alternative fuels. Likewise, building technologies integrate the use of renewable energy and energy-efficient technologies. Renewable energy technologies in the electric sector can also lead to total primary energy-demand savings, because of their greater efficiency in converting primary renewable energy into electricity—compared to conventional electricity production technologies.

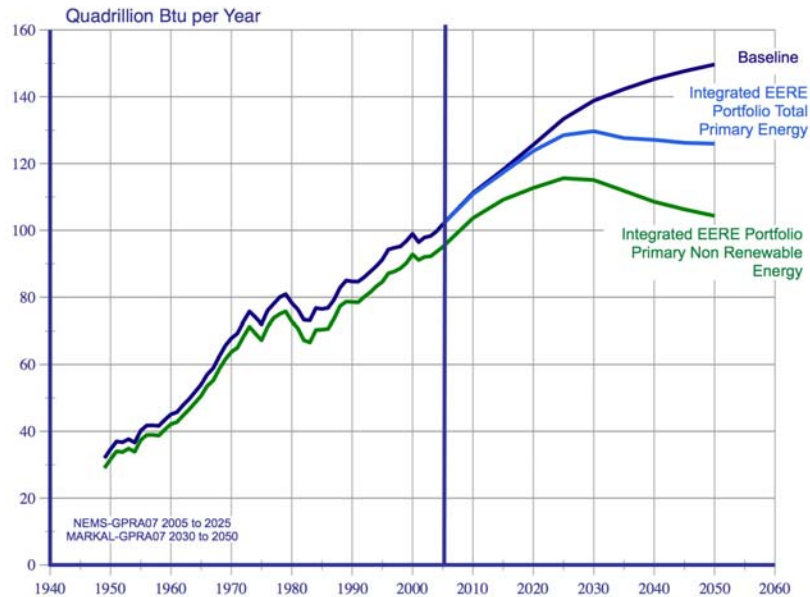


Figure 1.2 U.S. Total Energy Consumption versus Nonrenewable Energy Consumption, 1949-2005, and Projections to 2050: Baseline and Portfolio Cases

Data Source: 1949-2005, Energy Information Administration, *Annual Energy Review 2004*, DOE/EIA-0384 (2004) (Washington, D.C., August 2005), Table 1.1 Web site <http://www.eia.doe.gov/emeu/aer/contents.html>.

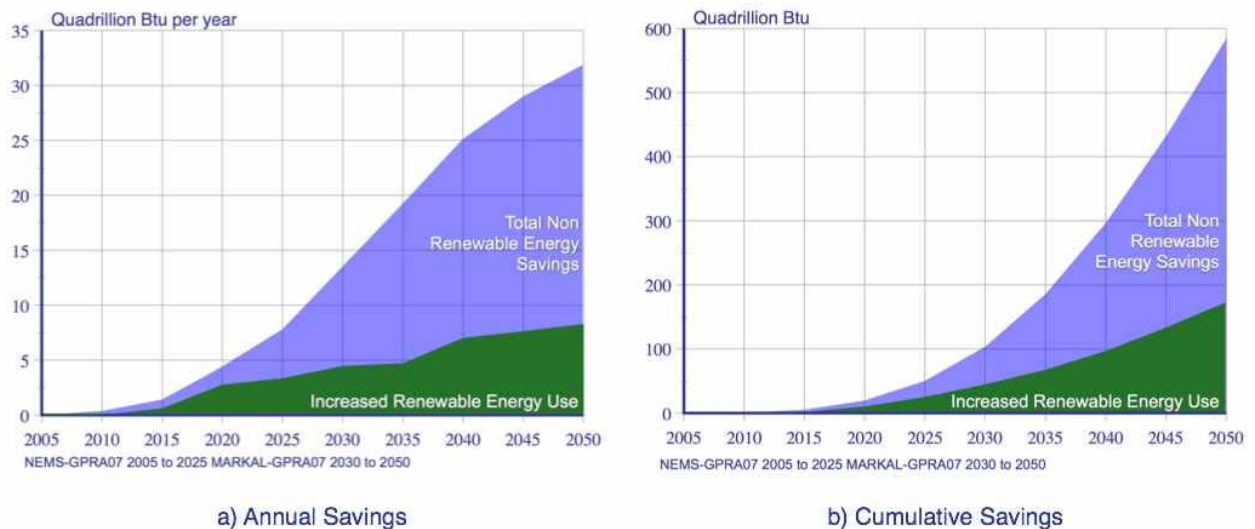


Figure 1.3 U.S. Total Nonrenewable Energy Savings and Total Renewable Energy Replacement Projections to 2050: EERE Portfolio Case

Economic Benefits: The NEMS-GPRA07 model estimates that energy savings to the consumer, resulting from these efficiency and renewable energy contributions, will reduce annual consumer energy expenditures in 2025 by \$130 billion (expressed in real 2003 dollars) relative to the baseline projection of \$1,050 billion (**Figure 1.4**), or about 12% of the

Nation's expected energy bill.

While these energy bill savings appear to be large, they represent both reduced energy purchases and lower energy prices resulting from reductions in demand. They also exclude incremental costs to end users of acquiring the new technologies, because the NEMS model does not currently have the capability to calculate this measure directly. Lower energy demand dampens fuel costs and reduces the need for expensive new energy infrastructure expenditures. Lower energy prices improve affordability for all consumers, including those who make no additional efficiency or renewable investments as a result of EERE's activities.

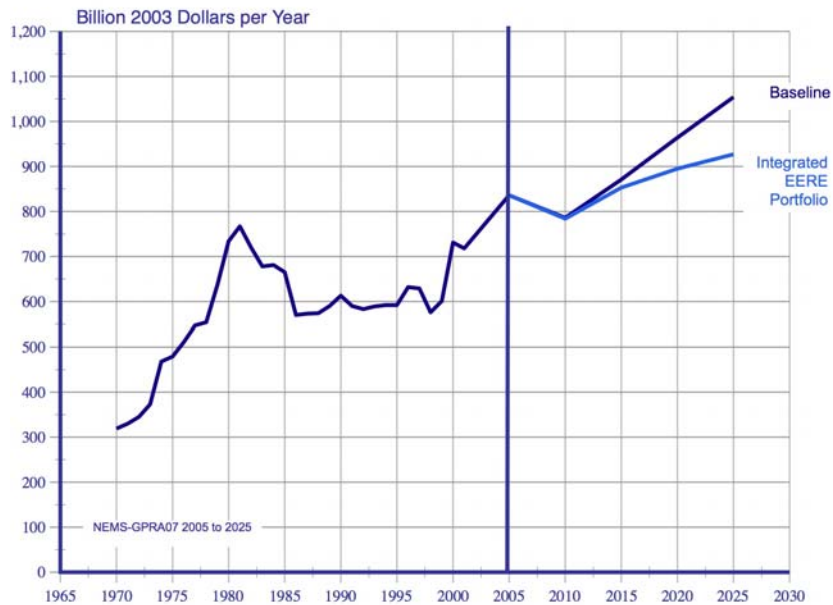


Figure 1.4. U.S. Total Energy Expenditure, 1970-2001, and Projections to 2025: Baseline and Portfolio Cases

Data Source: 1970-2001, Energy Information Administration, *Annual Energy Review 2004*, DOE/EIA-0384 (2004) (Washington, D.C., August 2005), Table 3.5 and Table D1, Web site <http://www.eia.doe.gov/emeu/aer/contents.html>.

The EERE portfolio also will reduce annual total system energy costs by more than \$200 billion (in real 2003 dollars) in 2050 (**Figure 1.5**). This longer-term analysis is done using MARKAL-GPRA07, which includes the incremental costs to end users of acquiring the new technology.

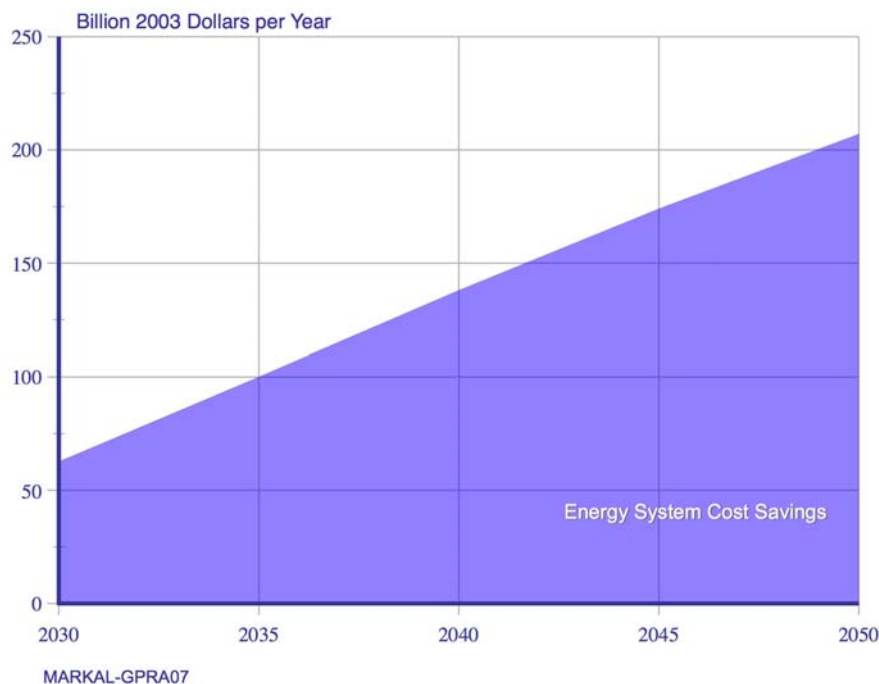


Figure 1.5 U.S. Total Energy-System Cost Savings 2030 to 2050

Environmental Benefits: Annual carbon emissions are projected to be 166 mmtce less than the 2025 baseline projection of 2,173 million metric tons—a reduction of about 8% (**Figure 1.6 and Figure 1.7a**), avoiding 32% of the expected increase from 2005 to 2025 in the absence of EERE’s technology programs. Annual carbon emissions are projected to be 606 million metric tons (carbon equivalent) less than the 2050 baseline projection of 2,532 million metric tons—a reduction of about 24%, or 68% of the expected increase from 2005 to 2050 without the benefits of EERE’s technology programs. During the period of 2008 to 2025, the EERE portfolio of energy efficiency and renewable energy technology avoids cumulative emissions of carbon to the atmosphere of 1 billion metric tons of carbon equivalent (see **Figure 1.7b**). From 2008 to 2050, cumulative avoided additions to the atmosphere are 12 billion metric tons of carbon equivalent.

The portfolio also provides State and local governments with additional options for meeting Clean Air Act ambient air quality standards. For instance, the Clean Cities activity in the Weatherization and Intergovernmental Program facilitates local purchases of alternative-fuel vehicles.

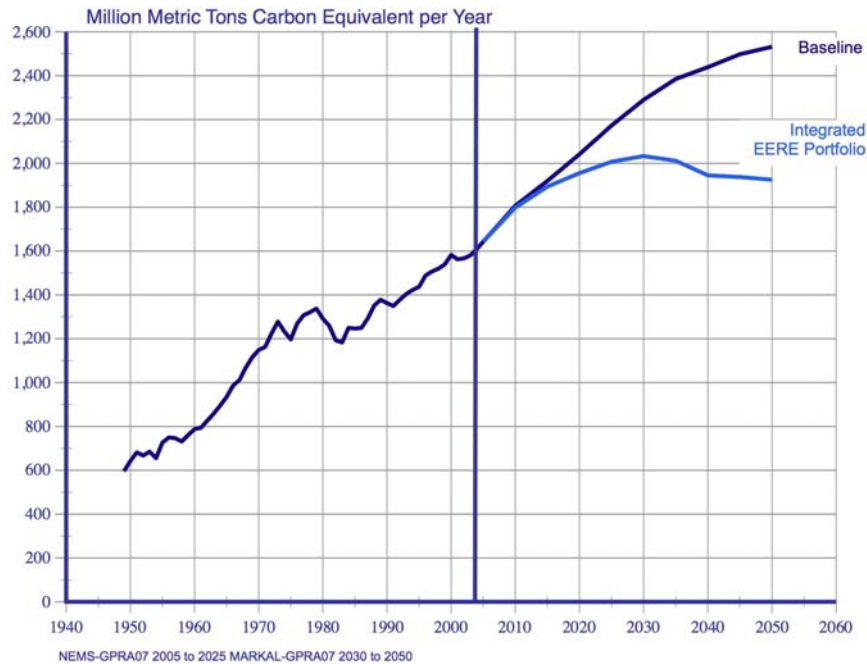


Figure 1.6. U.S. Carbon Emissions, 1980-2003, and Projections to 2050: Baseline and Portfolio Cases

Data Source: 1980-2000, Energy Information Administration, *Annual Energy Review 2004*, DOE/EIA-0384 (2004) (Washington, D.C., August 2005), Table 12.2, Web site <http://www.eia.doe.gov/emeu/aer/contents.html>.

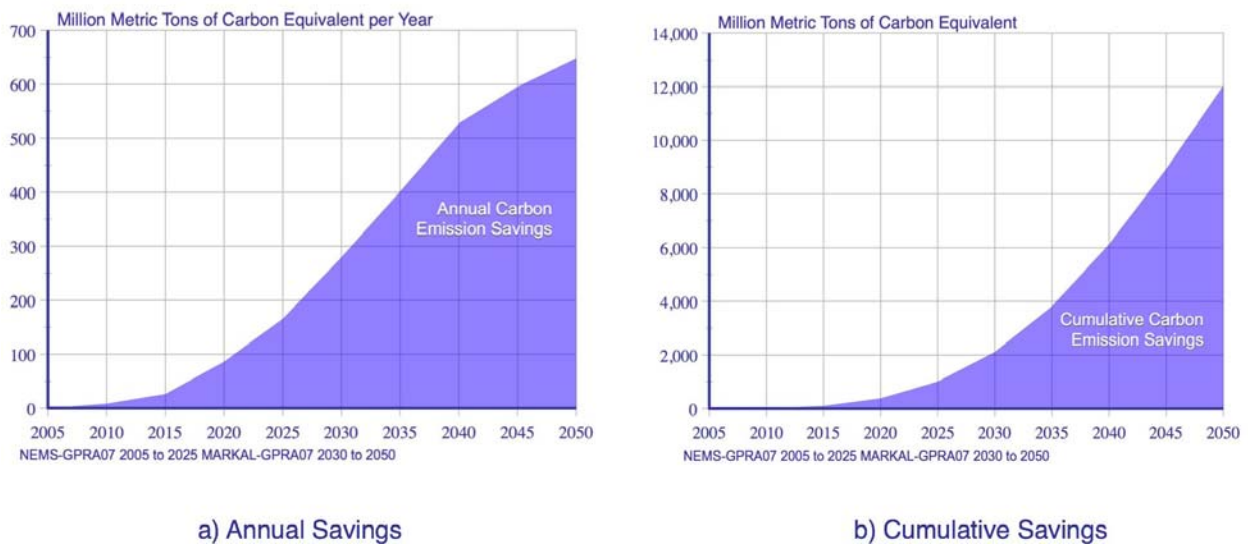


Figure 1.7. U.S. Carbon Emissions, 1980-2003, and Projections to 2050: Baseline and Portfolio Cases

Security Benefits: The largest relative impact of the EERE portfolio is on reducing the Nation's reliance on oil. The portfolio is expected to reduce annual oil consumption by 1.7

mbpd from the 2025 baseline of 25 million barrels per day (mbpd), or about 28% of expected growth in oil demand between 2005 and 2025 (**Figure 1.8 and Figure 1.9a**).

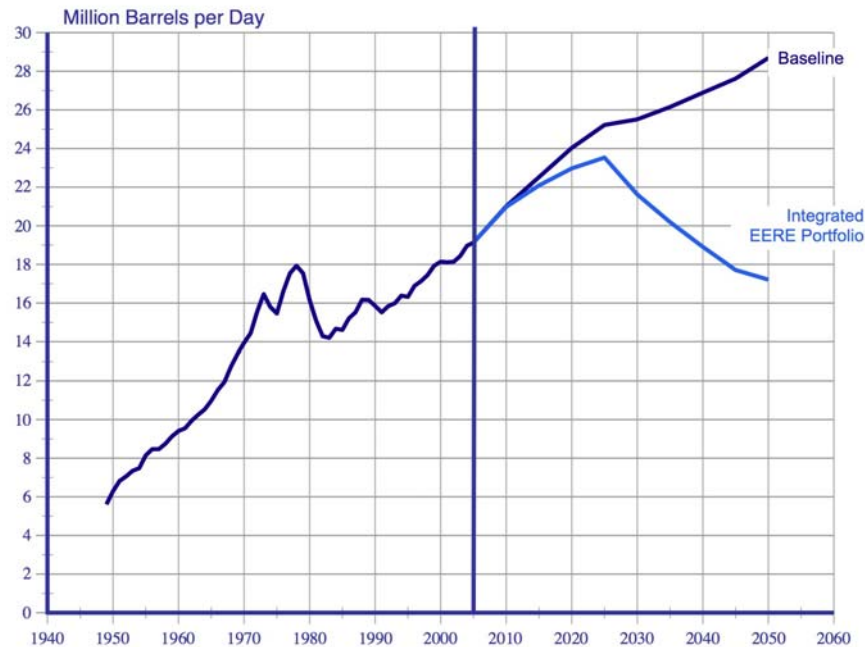


Figure 1.8. U.S. Oil Consumption, 1949-2004, and Projections to 2050: Baseline and Portfolio Cases

Data Source: 1980-2000, Energy Information Administration, *Annual Energy Review 2004*, DOE/EIA-0384 (2004) (Washington, D.C., August 2005), Table 1.3, Web site <http://www.eia.doe.gov/emeu/aer/contents.html>. Data were converted from quads per year to mbpd using conversion factor of 5.8 million Btus per barrel of crude oil.

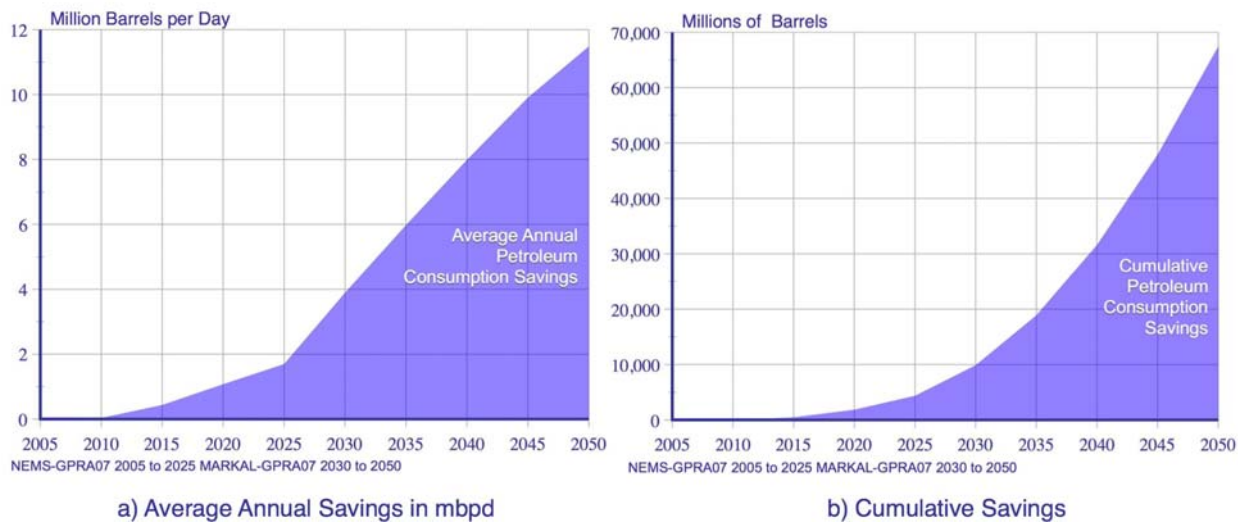


Figure 1.9. U.S. Oil Savings Projections to 2050: Baseline and Portfolio Cases

The portfolio is expected to reduce oil consumption by 11.5 mbpd from the 2050 baseline of 29 mbpd (about 120% of expected growth in oil demand between 2005 and 2050). This results in significantly declining oil consumption starting in 2030. Under the Portfolio Case, U.S. demand for oil would drop to levels not seen since the late 1970s. Over the period of 2008 to 2025, EERE's portfolio of technologies is projected to save a total 4.3 billion barrels of oil. From 2008 to 2050, cumulative oil savings would reach 67 billion barrels.

The oil savings projected under the Portfolio Case are nearly equivalent to reductions specifically in the projected demand for foreign oil. This is because almost all of the new U.S. demand for petroleum is projected to be met by foreign oil imports (see **Figure 1.10**).

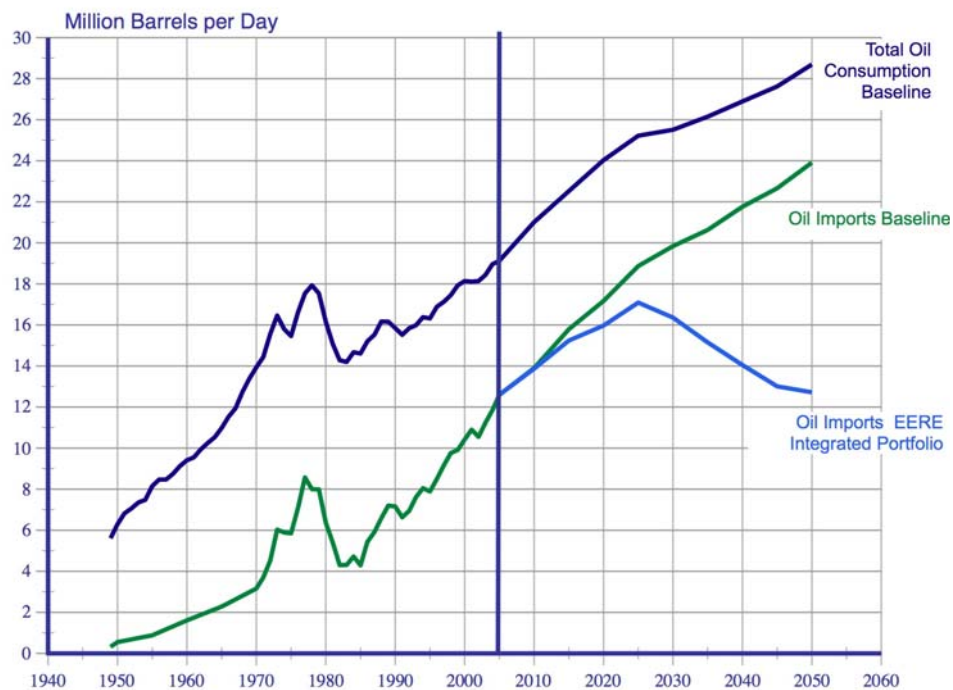


Figure 1.10. Foreign Oil Consumption, 1949-2004, and Projections to 2050: Baseline and Portfolio Cases

In the baseline projection, oil imports increase to 19 mbpd in 2025—equal to the total U.S. demand for oil in 2005. EERE's portfolio of technologies reduces foreign oil demand by 1.8 mbpd in 2025 (about 30% of expected growth in foreign oil imports in the baseline from 2005 to 2025). By 2050, projections for oil imports increase to 24 mbpd. EERE's programs would provide significant reductions in oil imports by 2050—cutting U.S. oil imports in half and eliminating all of the new growth in oil import demand for the period of 2005 to 2050.

While EERE's portfolio has elements that increase (as well as decrease) natural gas consumption; on balance, EERE's portfolio is expected to reduce annual natural gas consumption by about 0.8 quadrillion Btu from the baseline of 31 quadrillion Btu in 2025 and by 2.8 quadrillion Btu from the baseline of 38 quadrillion Btu in 2050 (**Figure 1.11 and**

Figure 12a). Over the period of 2008 to 2025, EERE’s portfolio of technologies provides 9 quads of cumulative savings of natural gas (**Figure 1.12b**).

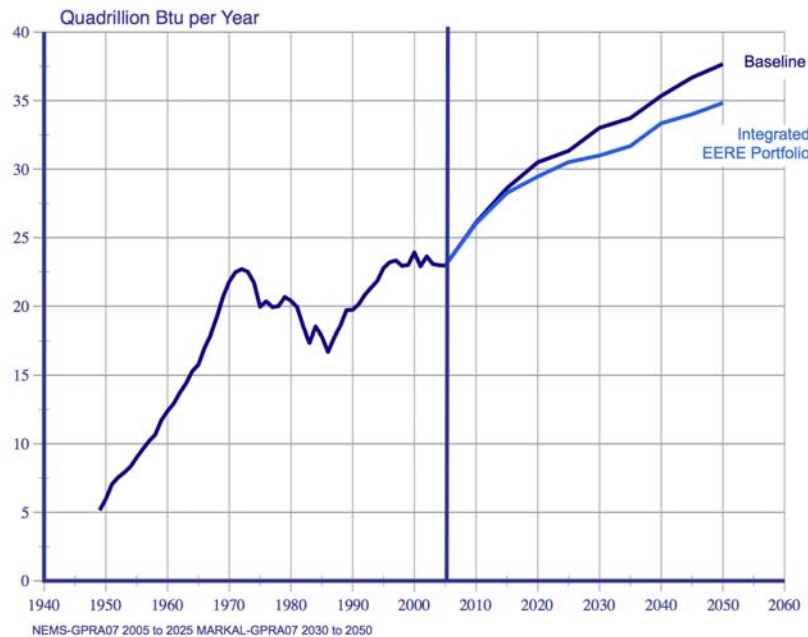


Figure 1.11. U.S. Natural Gas Consumption, 1949-2004, and Projections to 2050: Baseline and Portfolio Cases

Data Source: 1949-2004, Energy Information Administration, *Annual Energy Review 2004*, DOE/EIA-0384 (2004) (Washington, D.C., August 2005), Table 1.3, Web site <http://www.eia.doe.gov/emeu/aer/contents.html>.

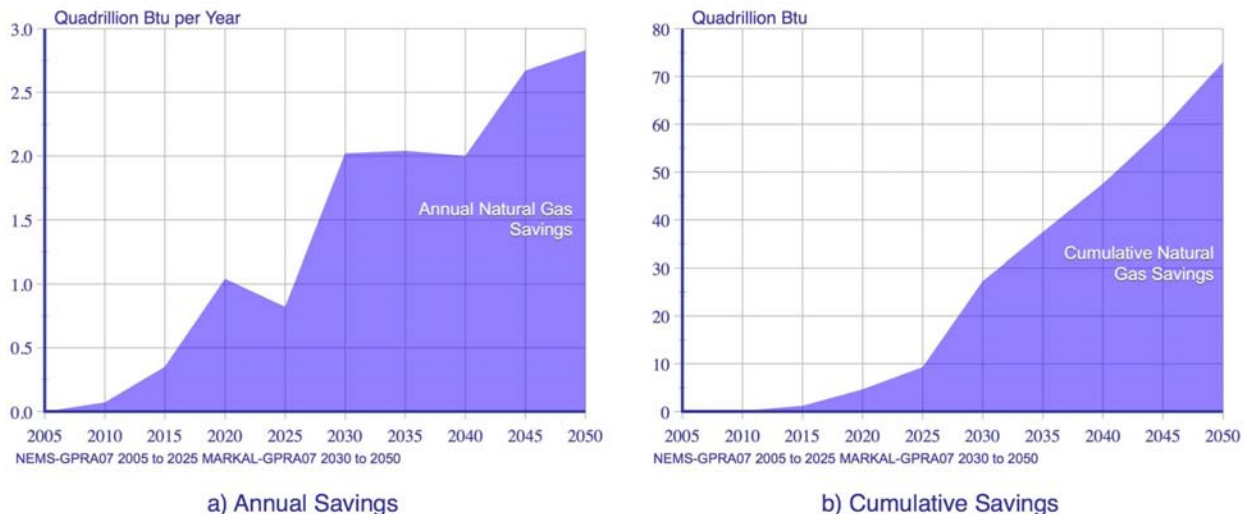


Figure 1.12. U.S. Natural Gas Savings, Projections to 2050: Baseline and Portfolio Cases

Cumulative savings of natural gas through 2050 is 73 quads. While EERE does not estimate the portion of natural gas savings attributed to imported natural gas supplies, supplies from

countries other than the United States and Canada may be the marginal sources of natural gas for meeting any future growth in demand.

EERE's technology programs also contribute to the security of the Nation's electricity supply by reducing central conventional power plant capacity additions (**Figure 1.13**). As shown in **Figure 1.14**, renewable energy capacity additions (central and distributed) are projected to grow by an additional 73 GW, compared with the Baseline Case in 2025; and 332 GW, compared with the Baseline Case in 2050.

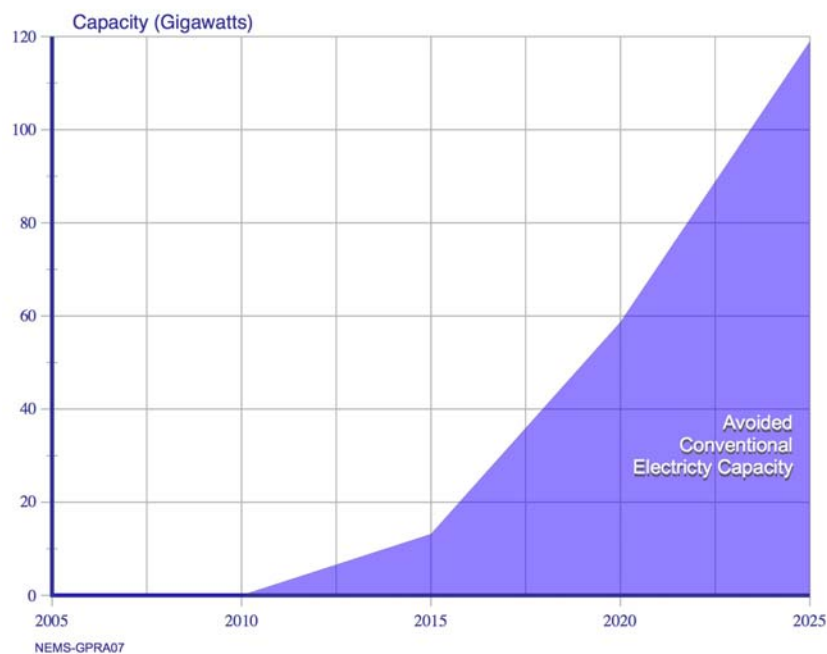


Figure 1.13. Avoided Conventional Central Generating Capacity Projections to 2025

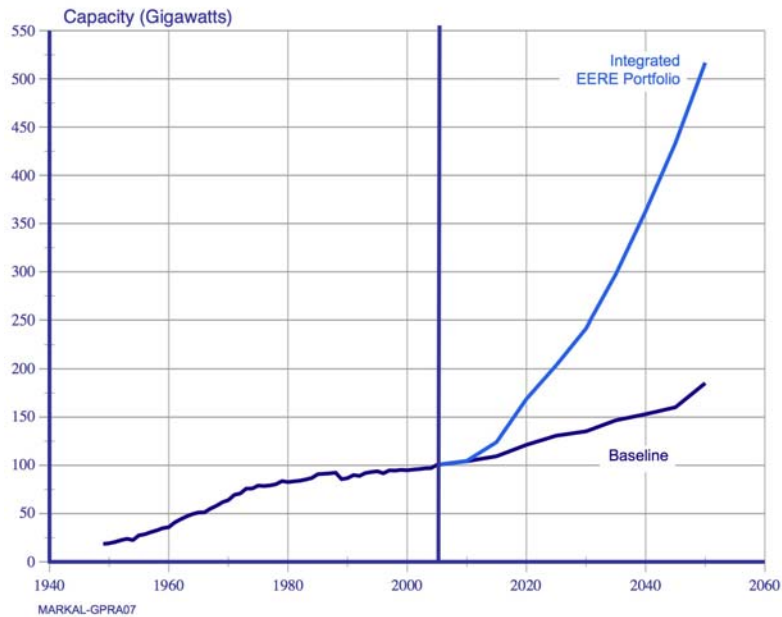


Figure 1.14. U.S. Renewable Energy Capacity, 1949-2004, and Projections to 2050: Baseline and Portfolio Cases

Data Source: 1948-2004, Energy Information Administration, *Annual Energy Review 2004*, DOE/EIA-0384 (2004) (Washington, D.C., August 2005), Table 8.11a, Web site <http://www.eia.doe.gov/emeu/aer/contents.html>.

Program Benefits

The remainder of this chapter is devoted to program-specific information, including program budget requests and benefits (see **Chapters 2 and 3** for more specific program-level analysis). **Figure 1.15** displays the EERE program budget requests for FY 2007. The largest program budget is \$225 million for the Weatherization and Intergovernmental Program (WIP), which includes \$164 million for Low-Income Weatherization Assistance.

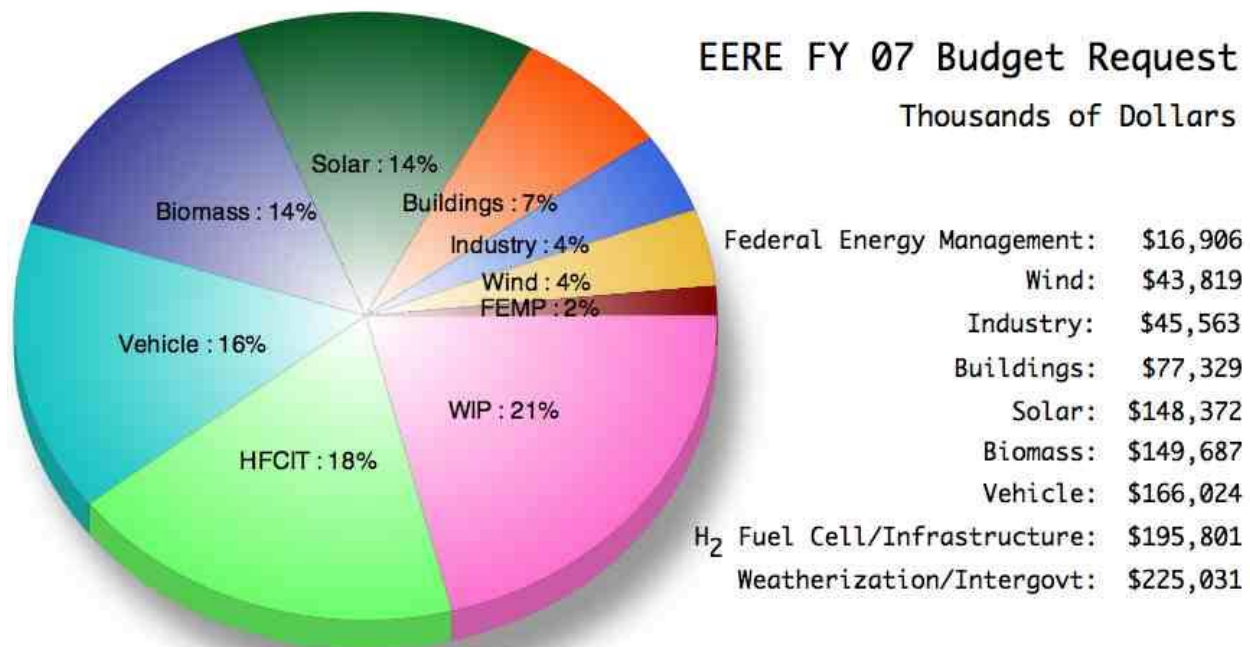


Figure 1.15. EERE Program FY 2007 Budget Requests

Source: Budget request from *FY 2005 Budget-in-Brief*, U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, http://www1.eere.energy.gov/ba/pba/budget_07.html

Individual program benefits are not—as indicated in the earlier discussion on primary nonrenewable energy savings—in sum, representative of the total benefits of the integrated EERE technology portfolio. That is because individual programs can compete with or be synergistic with other programs in the portfolio—and the individual program benefits presented here represent how each program’s technologies can compete by themselves, without the presence of any other programs in the EERE portfolio. Still, the individual program benefits presented here serve as a proxy for understanding the relative strengths of each program’s technology.

The picture that emerges from the individual program benefits presented here is one of robustness. Different technologies are positioned to dominate in the near, mid- and long term.

Some technologies are best-suited to improving energy security by reducing our dependence on foreign oil. In addition, different programs emerge as important contributors to consumer energy savings versus those that emerge as important contributors to total energy system net cost savings.

While incomplete, the results indicate both the range and approximate level of benefits available to the Nation from funding the efficiency and renewable investments in EERE's portfolio of programs. They indicate a potential for making better use of existing technologies and for accelerating technological advances to make significant changes in our energy markets, which can drive the Nation to a period of level energy consumption.

Energy Displacement: Figures 1.16 a and b show the time profile of each program's savings (both annual and cumulative). The relative cumulative impact of the individual program cases is shown in Figure 17 for three different time frames (2015, 2025, and 2050). The Industry, WIP, and FEMP programs have their greatest influence in the near term (through 2015). The Building Technologies Program has the largest impact in the near term, followed closely by the Vehicle Technologies Program, the Biomass Program, and Weatherization. In the midterm (through 2025), the Wind Technologies Program shows the greatest relative impact on energy savings. In the long term, advanced transportation technologies (from Hydrogen, Vehicles, and Biomass) become the dominant potential impacts. In the meantime, solar technologies show continuous growth in relative impact throughout the period of 2008 through 2050. By 2050, Vehicles, Buildings, Wind, Solar, Hydrogen, and Biomass (in descending order) each have significant potential impacts on energy displacement.

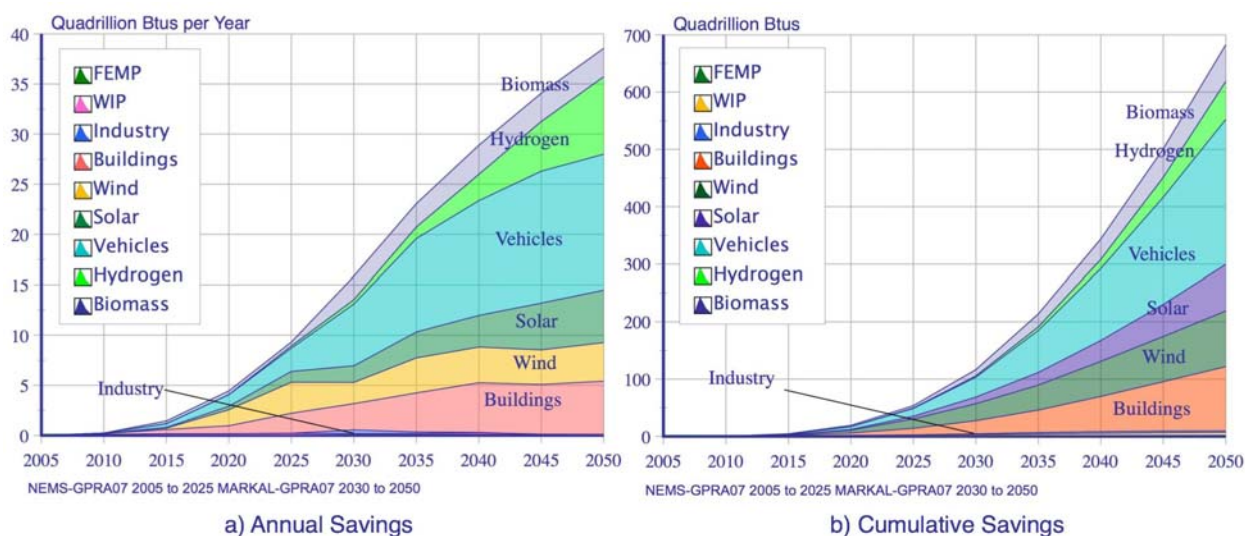


Figure 1.16 Individual Program Goal Cases Nonrenewable Energy Savings: Annual and Cumulative

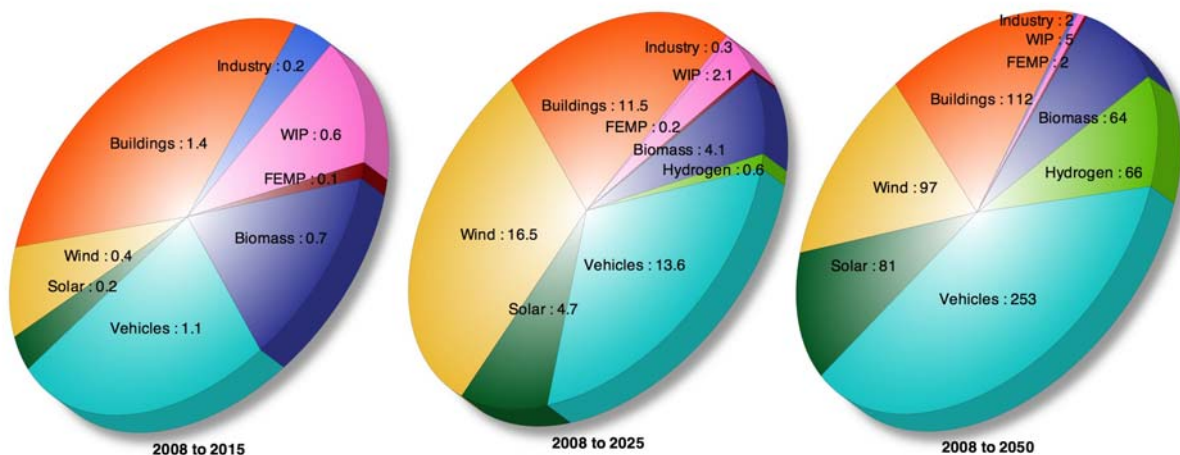


Figure 1.17. Cumulative Individual Program Goal Cases Nonrenewable Energy Savings for 2015, 2025, 2050 (Quadrillion Btu)

Economic Benefits: Figure 1.18 shows the time profile of the individual program impacts on consumer energy spending through 2025. As with energy displacement, energy-expenditure savings are dominated in the near term by the Building Technologies Program, followed closely by savings impacts from the Vehicle Technologies Program. By 2025, the largest individual program savings are associated with the Vehicles Program. Buildings, Wind, Solar, and Biomass are also positioned to have significant impacts. The Hydrogen Program is just beginning to show potential impact. Figure 1.19 shows the time profile of the individual program impacts on total energy system cost. Here, the relative strengths of the different programs play out very differently. Total energy cost, as opposed to consumer spending, is most heavily influenced by energy efficiency technologies. Thus, in the near- and midterm, the Buildings Program dominates the savings. In the long term, energy savings from the Vehicles Program and the Buildings Program dominate.

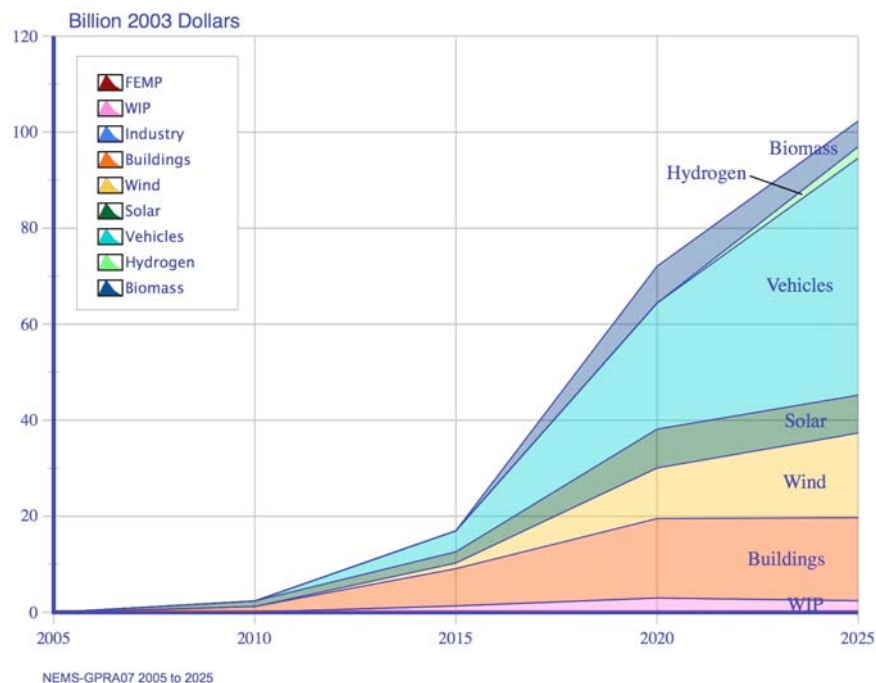


Figure 1.18. Annual Individual Program Goal Cases Consumer Energy-Expenditure Savings: Projections to 2025

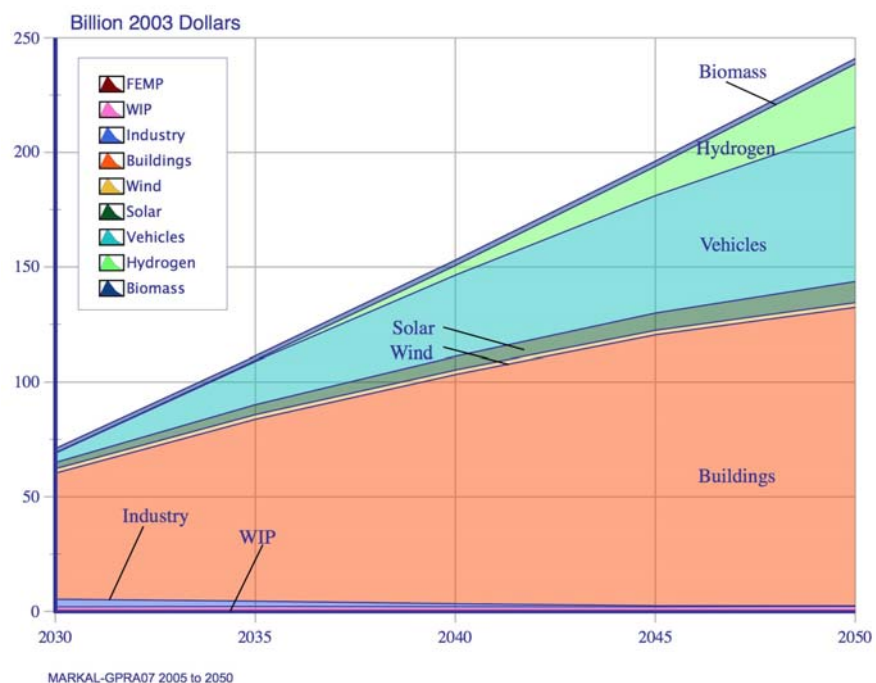


Figure 1.19. Annual Program Goal Cases Energy-System Net Cost Savings: Projections to 2050

Environmental Benefits: The time profiles and relative impacts of each of the programs on carbon emissions follows very closely the trends described for total nonrenewable energy savings (see **Figures 1.20 and 1.21**).

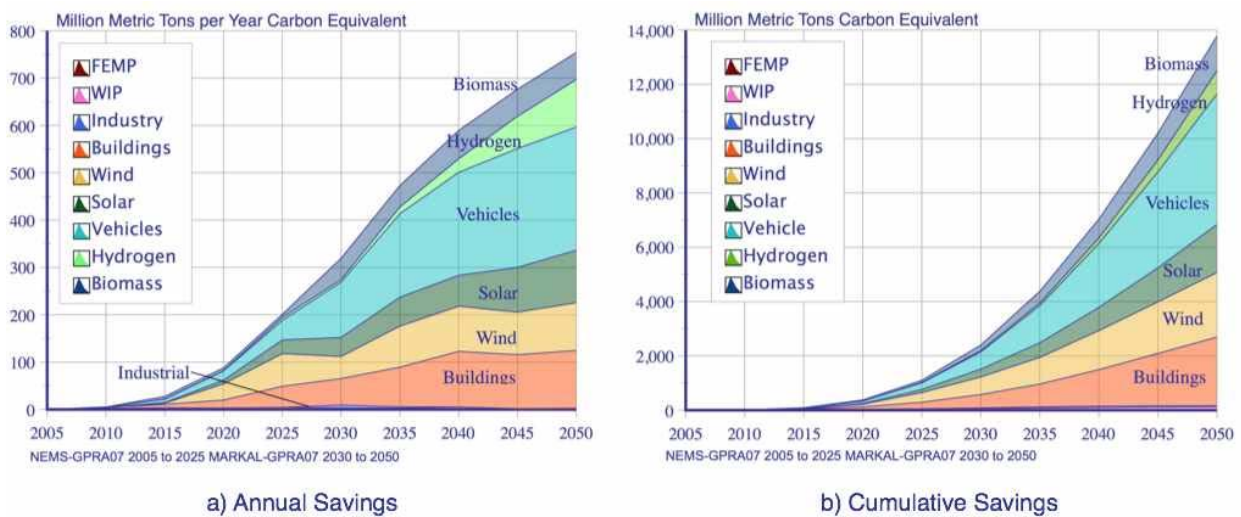
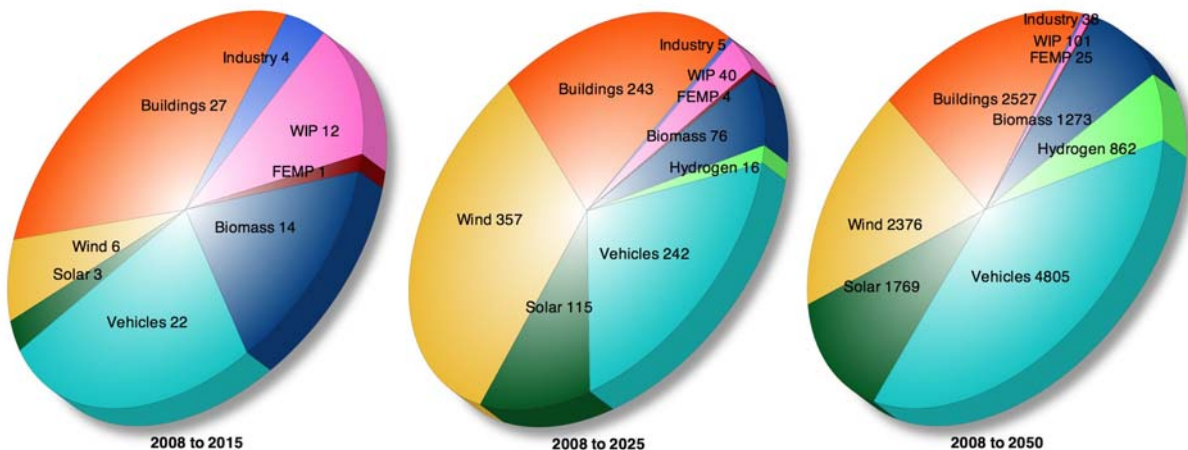
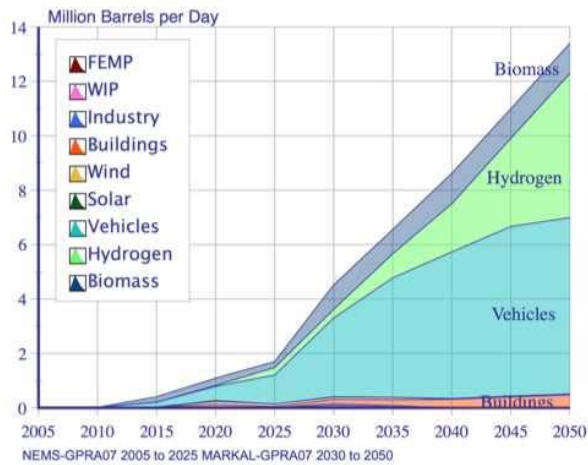


Figure 1.20. Individual Program Goal Cases Carbon Emissions Avoided: Annual and Cumulative

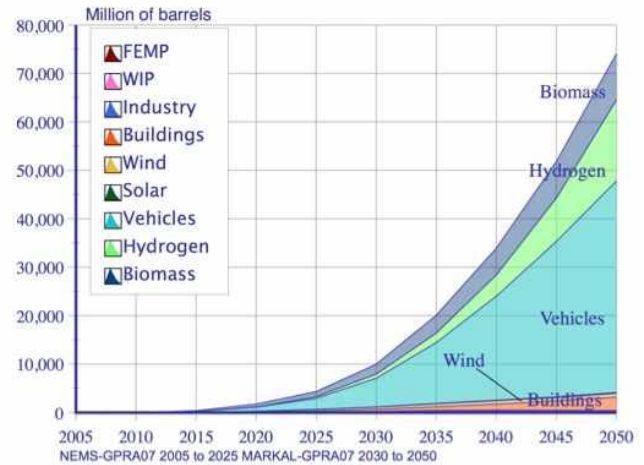


Figures 1.21. Cumulative Individual Program Goal Cases Carbon Emissions Avoided, 2015, 2025, 2050 (Million Metric Tons Carbon Equivalent)

Energy Security Benefits: Oil savings are dominated by the three main transportation related technologies—Vehicles, Hydrogen, and Biomass (see [Figures 22 and 23](#)). In the near term, the Vehicles and Biomass programs are equally positioned to dominate oil savings in the portfolio. In the long term, Hydrogen steps forward as the third major technology positioned to contribute to oil savings.

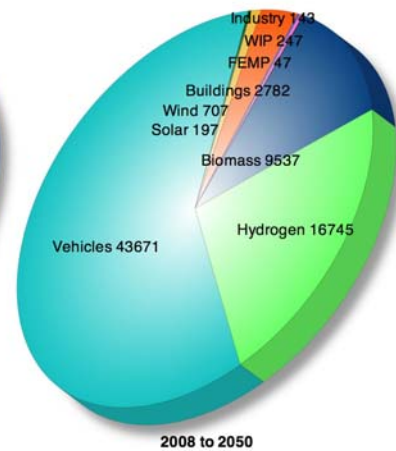
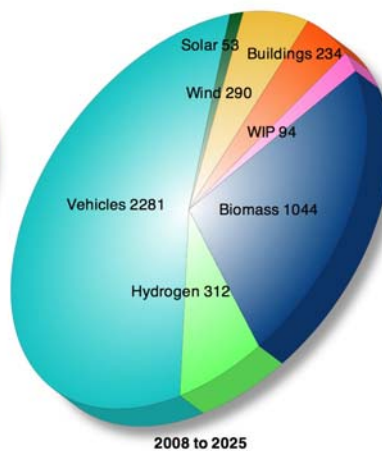
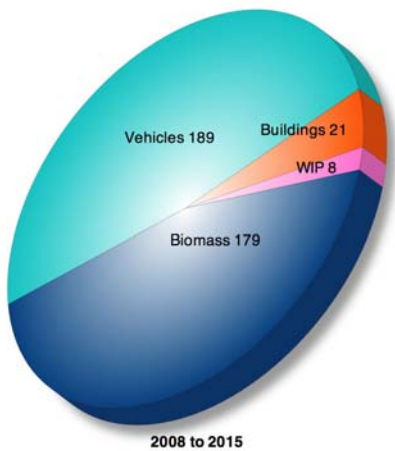


a) Annual Savings



b) Cumulative Savings

Figure 1.22 Individual Program Goal Cases Oil Savings (mbpd)



Figures 1.23: Cumulative Individual Program Goal Cases Oil Savings (Millions of Barrels)